3.3 ENERGY AND NATURAL RESOURCES

3.3.1 Studies and Coordination

The Caltrans document *Energy and Transportation Systems* (Caltrans, 1983 and 1993) was reviewed for applicable formulas and data related to energy consumption.

Energy is consumed during the construction and operation of transportation facilities. Energy is used during construction to manufacture materials and transit vehicles, transport materials, and operate construction machinery. Operational energy consumption includes fuel and electricity consumed by public and privately-operated vehicles using the facility, a negligible amount of electricity for signals and lighting, and the inherent losses of energy during transmission. Operational energy consumption impacts are evaluated by qualitatively comparing vehicle energy consumption among alternatives.

Energy consumption rates for vehicles operating on the roadway can be differentiated by comparing changes in traffic operations, as measured by vehicle miles traveled (VMT) and changes in traffic speed throughout the study area. Fuel consumption is proportional to distance traveled, and decreases as speed increases up to about 60 kilometers per hour (40 miles per hour). Fuel consumption increases as speed increases above that point (U.S. Department of Transportation, 1980). Energy consumption estimates for roadway traffic within the affected area are based on the traffic impact analyses prepared for the I-405 Corridor Study. For Alternatives 1 and 2, which include a high-capacity transit (HCT) system, the energy required to operate a physically separated, fixed-guideway HCT system, assuming some form of rail technology using electric propulsion, was estimated separately and added to the estimate for traffic. The alternatives are compared based on daily differences in energy consumed by all traveling vehicles (U.S. Department of Transportation, 1980).

3.3.2 Methodology

Common units of energy measurement are joules and British thermal units (BTUs). One joule is the equivalent of .95 BTU. Because these are relatively small units, energy is often reported in terajoules (1,000,000,000,000 joules). Energy consumption during construction in the corridor is discussed based on the estimated construction cost of the improvements. Energy consumption to complete a project is proportional to the cost of the project. An approximate construction energy consumption factor, adjusted to year 2000 dollars (using the construction price index reported by the *Engineering News Record*) for urban freeway expansion widening is about 10 terajoules per one million dollars of construction cost (Caltrans, 1983). For HCT systems, a construction energy estimate of 21 terajoules per track mile constructed was used (Caltrans, 1983). This figure includes the installation of track and power systems for the fixed-guideway HCT system.

Estimates of operational energy consumption for vehicles operating on the roadway are based on the operational traffic impact analyses prepared for the EIS. Net changes in overall energy use by roadway vehicles are assessed using daily VMT and average speed values calculated from the transportation forecasting model for each alternative. Energy consumption is calculated by multiplying daily VMT by the appropriate fuel consumption rate for the average speed. Estimates of operational energy requirements for the fixed-guideway HCT system are based on calculations of direct propulsion energy, as well as indirect energy needs such as energy lost during transmission from the energy generation site to the HCT vehicles.

Energy calculations for rail HCT systems can involve a large number of variables. These variables include vehicle size, type, weight, and efficiency; passenger-related load factors; system grade; spacing of stations; operational issues such as acceleration, deceleration, and top and average speeds; throttle positions; horsepower to weight ratio; deadheading requirements; etc. These variables result in a wide range of operational energy requirements. For instance, one of the principal variables has been found to be station spacing. Energy requirements tend to increase with reduced distances between stations. This variable alone can create substantial variation in energy intensity throughout a system even for the same vehicles.

Due to the programmatic level of analysis and the complex nature of developing precise calculations of direct propulsion energy, an estimate of direct energy was developed based on a range of light rail HCT energy intensity findings from other studies. An estimate based on such a range is understood to be very broad.

Caltrans published a report that delineated its estimation methodology for propulsion energy calculations and cited a light rail HCT energy intensity range of 50,000 to 100,000 BTUs per vehicle-mile that was developed by the Congressional Budget Office (Caltrans, 1983). Assuming a mid-range energy intensity of 75,000 BTUs per vehicle-mile, daily fixed-guideway HCT energy consumption would be approximately 1.9 terajoules per day based on 24,200 HCT vehicle-miles per day in 2020. This is approximately 1 percent of the energy consumed by vehicles operating on study area roadways.

Analysis of an electrically driven transportation system also includes conversion of energy from a power generation plant to the HCT vehicles. This includes typical losses due to generation, transmission, and conversion of alternating to direct current. A conversion energy factor of 27.4 percent was used in this analysis based on 1983 studies conducted by Caltrans.

The maximum loading period for light rail HCT systems tends to occur during the afternoon peak. If the addition of the fixed-guideway HCT load requires the supplying utility to purchase load-matching generation, the additional load may be purchased in relatively fuel-intensive units, such as gas turbines, without waste heat recovery. Should a sizable portion of the fixed-guideway HCT operating energy be generated in this manner, the overall efficiency factor would be lower than assumed in this calculation and energy requirements would be greater than reported.

The energy analyses in this section are based on the *I-405 Corridor Program Draft Energy Technical Memorandum* (Parsons Brinckerhoff, 2001), herein incorporated by reference.

3.3.3 Affected Environment

The I-405 corridor is one of the primary north-south transportation corridors in the Puget Sound region. It connects with I-5 at both its north and south terminus, bypassing the Seattle urban core. In 1999, I-405 carried up to 210,000 vehicles per day on some sections.

3.3.4 Impacts

3.3.4.1 No Action Alternative

Construction Impacts

Energy would be consumed during construction of any of the alternatives to manufacture materials, transport materials, and operate construction equipment. Estimated construction energy consumption is presented in Table 3.3-1. The No Action Alternative includes construction of planned and committed transit and roadway projects in the I-405 corridor. The energy expended for construction under the No Action Alternative would be substantially less than that for any of the action alternatives because of the comparatively smaller amount of construction that would occur.

Table 3.3-1: Construction Energy Consumption

Alternative	Energy Consumption During Construction (Terajoules)
No Action	4,700
1: HCT/TDM Emphasis	
Roadway	8,000
Fixed-Guideway HCT	2,390
Total	10,390
2: Mixed Mode with HCT Emphasis	
Roadway	32,800
Fixed-Guideway HCT	2,390
Total	35,190
3: Mixed Mode Emphasis	50,300
4: General Capacity Emphasis	96,200
Preferred	60,800

Operational Impacts

Traffic is predicted to increase by the year 2020, independent of the I-405 Corridor Program. Vehicle fuel consumption dominates the total energy use for each alternative, and is largely determined by daily VMT and speed. Thus, these two measures were used to estimate the operational energy consumption among the alternatives. Energy consumption resulting from daily vehicle operations in the affected area is presented for the No Action Alternative and five action alternatives for 2020 in Table 3.3-2. Operational energy consumption would be 1 percent less than the No Action Alternative for Alternative 1, 5 percent greater for Alternatives 2 and 3, 9 percent greater for Alternative 4, and 6 percent greater for the Preferred Alternative.

Table 3.3-2: Daily Operational Energy Consumption

Alternative	Daily Fixed-Guideway HCT Vehicle Miles Traveled	Daily Vehicle Miles Traveled on Roadway	Study Area Average Roadway Speed (mph)	Fuel Consumption Rate (gallons per mile)	Gasoline Consumption (gallons)	Energy Consumption (terajoules)	Change in Energy Consumption Relative to No Action
No Action Alternative	0	22,510,000	19	0.042	945,000	129	N/A
1: HCT/TDM Emphasis	24,200	22,563,000	20	0.041	925,000	128	--1 percent
2: Mixed Mode with HCT/Transit Emphasis	24,200	24,215,000	21	0.040	969,000	135	+5 percent
3: Mixed Mode Emphasis	0	25,346,000	22	0.039	988,000	135	+5 percent
4: General Capacity Emphasis	0	26,208,000	22	0.039	1,022,000	140	+9 percent
Preferred Alternative	0	25,697,000	22	0.039	1,002,000	137	+6 percent

3.3.4.2 Action Alternatives

Construction Impacts

Each of the action alternatives would expend energy to manufacture and transport materials, and operate equipment during construction of the transit and roadway improvements. As shown in Table 3.3-1, the relative amount of construction energy required increases substantially under each of the action alternatives proportional to its cost and the magnitude of the improvements. Overall, these values are a very small fraction of the energy consumed annually for transportation in the state of Washington, and would not put substantial additional demand on energy sources or fuel availability in the region.

Operational Impacts

Each action alternative would add a different level of capacity in the I-405 corridor in different ways. As shown in Table 3.3-2, differences in energy consumption resulting from daily vehicle operations in the affected area would range from 1 percent less than the No Action Alternative for Alternative 1, to 9 percent greater than the No Action Alternative for Alternative 4. These values are not expected to substantially affect energy sources or fuel availability in the region.

3.3.5 Mitigation Measures

Measures to reduce energy consumption during construction could include limiting the idling of construction equipment and employee vehicles, encouraging carpooling or van pools among construction workers, and locating construction staging areas as close as possible to work sites. Any transportation control measures to reduce traffic volumes and congestion would also decrease energy consumption.